1.2 Biotic Factors: The Influence of Living Things

Figure D1.10: Bison used to roam the prairies.

There was a time when from 30 to 60 million bison roamed the grasslands of North America. Until about 200 years ago, these large and powerful animals were the most numerous grazing animals on the planet.

You may be surprised to know that in its natural state, one hectare of prairie grassland produces more **biomass** each year than one hectare of the most technologically advanced wheat field. As an illustration, the number of kilograms of bison supported by 100 km^2 of prairie grassland was greater than the number of kilograms of grazing cattle that can be raised on 100 km^2 of a modern ranch. If you find all this puzzling, you may be amazed that many biologists suspect the prairie dog played a key role in the success of the bison on Alberta's grasslands.

biomass: the dry mass of all the living organisms occupying a habitat

Figure D1.11: Black-tailed prairie dogs are suspected of playing a key part in the success of bison on Alberta's grasslands.

Why were bison so perfectly matched to the prairie landscape? How could two animals as different from one another as prairie dogs and bison be so interconnected? The answers have to do with the **ecology** of the prairie ecosystem. Since an ecosystem includes not only all the organisms but also all the abiotic factors from an area, it makes sense to start with the origins of the bison within the changing prairie environment.

ecology: the study of the interactions of living organisms with one another and with their physical environment

ORIGINS OF THE BISON WITHIN THE CHANGING PRAIRIE ENVIRONMENT

Time	Event
55 to 170 million years ago	• The Rocky Mountains are formed by collisions between the North American Plate and arcs of volcanic islands. Dinosaurs lived in central North America until about 65 million years ago. • A barrier is created that blocks moist air from the Pacific Ocean from entering central regions of North America. The great plains of North America become drier.
1.7 million years ago	• Several periods of glaciation begin. Parts of Alberta are covered in ice up to one kilometre thick.
10 000 years ago	• A sudden climate change causes the glaciers to retreat. • A climate of drier and warmer summers followed by colder winters favours grassland vegetation.
8000 to 10 000 years ago	• The climate change and pressure from human hunters are believed to have contributed to the extinction of several large mammals—mammoths, mastodons, and giant sloths. Caribou, musk-oxen, and bison survive both the hunting pressure and the climate change. • Vacancies in the food chain allow bison to thrive. • Life for First Nations people living on the prairie grasslands begins to revolve around the seasonal movements of bison herds. Bison provide food, bones for tools, and hides for clothing and teepees.
6000 years ago	• Head-Smashed-In Buffalo Jump is first used by First Nations people to kill large numbers of bison. The bison are chased over a cliff.
5000 years ago	• Bison become the dominant herbivore of the prairie landscape. • First Nations people continue to develop and improve techniques for harvesting bison.
1850	• Approximately 40 million bison inhabit the central plains of North America.
1900	• Fewer than 1000 bison remain.
2000	• The bison population is about 200 000.

Practice

9. About 65 million years ago, the geological processes responsible for building the Rocky Mountains were still underway. Identify the type of animals that dominated the central plains of North America up to this time.
10. Describe the circumstances that allowed the bison to become the dominant herbivore of the prairie landscape.
11. Use the Internet as a research tool to find out why the Head-Smashed-In Buffalo Jump was designated by the United Nations Educational Scientific and Cultural Organization (UNESCO) as a World Heritage Site. Other World Heritage Sites include the Egyptian pyramids, Stonehenge, and the Galapagos Islands.

Use the following information to answer questions 12 to 14.

Archaeological evidence of the First Nations people who inhabited Alberta for more than 500 generations can be found at thousands of sites across Alberta. Some of the most intriguing types of artifacts are the rings of stone known as medicine wheels.

Figure D1.12: People have varying ideas about the actual purposes of medicine wheels.
An actual medicine wheel is pictured on the left, while an artist's representation is on the right.

A medicine wheel consists of a central cairn of rocks surrounded by one or two concentric rings of stones ranging from 10 m to 30 m in diameter. Radiating out from the central cairn are lines of stones from 3 m to 120 m long. The radiocarbon dating of bone fragments and studies of other artifacts, such as spear tips, found at these sites have led archaeologists to conclude that some of the medicine wheels are more than 4000 years old. This makes them about the same age as the Great Pyramids of Egypt. What archaeologists do not know is the purpose of these medicine wheels. The central cairn of rocks in some medicine wheels appears to be a burial lodge. Other medicine wheels may have been used for ceremonial functions—this includes the Sundance ceremony of the Blackfoot or Siksikaitsitapi.

One intriguing hypothesis is that some of the medicine wheels may have been used for astronomical purposes. In some of the medicine wheels, the rock arrangement allows for a precise alignment of the Sun rays at sunrise on the summer solstice—the year's longest day. There are similarities between medicine wheels and other ancient structures that were thought to act as calendars—such as Stonehenge in England.

Although medicine wheels may have been used for a number of different purposes, these sites are all considered to be sacred places. The medicine wheels that have been built in recent times share this legacy. First Nations elders have explained that they commemorate the lives of brave warriors or great hunters.

12. The First Nations people who lived on the prairie grasslands moved from camp to camp. They followed the herds of bison on which they depended so heavily. How does this lifestyle explain why so little archaeological evidence is left?
13. Given your answer to question 12, explain why sites such as medicine wheels have to be treated with such care and respect.
14. Relate some possible reasons why knowing the exact passing of the longest day of the year would be so important to First Nations people.

Life at the Surface of the Prairie and Below

Figure D1.13: Natural prairie grassland is not so common anymore in western Canada.

population: a group of organisms, all of the same species, which interbreed and live in the same area at the same time

The bison **population** clearly played a central role in the lives of people who inhabited Alberta's prairie landscapes. In turn, bison were supported by the very grasses that comprised the landscape. Prairie grassland usually contains more than 100 plant species and many animal species.

Figure D1.14: The roots of some prairie grasses can extend 3 m to 4 m deep into the soil, binding the soil tightly to the earth and protecting it from erosion. The roots found in a square metre of prairie soil just 10 cm deep would stretch for over 30 km if they were connected from end to end.

Most of these plants are perennials with extensive root systems that extend far below the surface. The soil that supports these plants is regarded to be among the deepest, most productive, and most fertile soil on the entire planet. You may be surprised to learn that the tiny organisms living in the soil beneath the grassland's surface have a larger total biomass than the larger animals that live above ground.

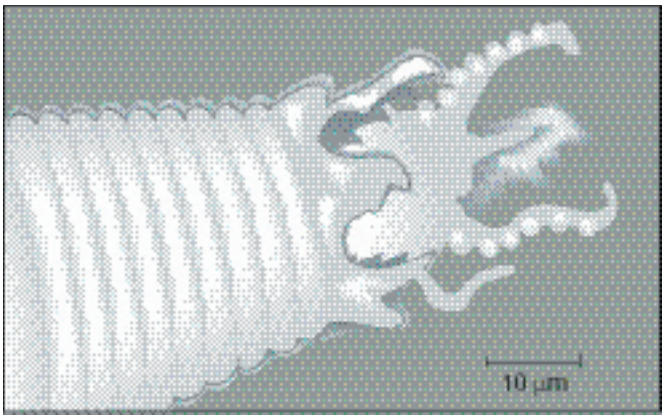


Figure D1.15: This is an artist's drawing of the head of a nematode.

Tiny worms called nematodes—most are less than 4 mm long—come in a number of varieties. Some eat the roots of plants, others feed on fungi, while the species shown in Figure D1.15 feeds on bacteria. It is possible to find five million nematodes per square metre of prairie soil. What these organisms lack in size, they make up for in numbers. They collectively consume more biomass than the huge herds of bison that once grazed over them.

Figure D1.16: Growths on the roots of this plant contain bacteria that make nitrogen available to the plant. The plant, in turn, provides a site for the bacteria to live, as well as nutrients for the bacteria through its roots.

Even more numerous are the bacteria, fungi, and other microscopic life forms that convert key nutrients, such as nitrogen and phosphorus, into forms that can be used by the grasses. These organisms do this by decomposing organic matter, such as dead leaves and animal droppings, in the soil. Without these micro-organisms, there would be insufficient nutrients to support the grasses and, therefore, there would be an absence of the food source for bison, cattle, and indirectly for people.

The prairie grasses and all the organisms that live and grow in the soil with them form a **biological community**. The word *community* is appropriate because it implies both a physical closeness and interconnections between the populations. If an analogy were made to human communities, an organism's habitat would be its address in the community.

biological community: interacting populations living in a certain area at a certain time

Practice

15. Identify some of the abiotic factors—in the form of nutrients—provided to prairie grasses by the micro-organisms that live in the soil.
16. Concisely explain why the huge herds of bison that once roamed the prairie ecosystem could not have existed without the micro-organisms that lived in the soil.

Prairie Dogs

Figure D1.17: Prairie dogs make barking sounds.

Prairie dogs were named for the puppy-like yip they bark out when they are approached. This is why some of the early European settlers called them *sod poodles*. These social animals live in a system of burrows called towns. The burrows usually have one main entrance mound and at least one exit hole to allow for air circulation and a fast escape from a predator. Prairie dogs prefer to live in places that are free of shrubs and other obstructions so they can have a long, unobstructed view of their surroundings and can see predators coming. This is why prairie dogs eat any vegetation that grows too high.

All the tunneling it takes to create a prairie-dog town has a profound effect on other species. Burrowing alters the soil chemistry by aerating the soil and by mixing in plant and animal wastes. This churning of the soil has the effect of increasing the nutrient value of the soil to enhance plant diversity and productivity. The spinoff of all this activity is that prairie-dog towns are recognized by more than 150 other species of animals and insects as being the grocery store of the prairies—an excellent source of food variety. These other species may live in the burrows, eat prairie dogs, feed on nutritious plants that live in this area, or feed on insects that can be more easily found in the short vegetation. There are more than twice as many birds found near prairie-dog towns as there are in areas with no prairie dogs.

Historically, bison were known to graze on prairie-dog towns—they preferred to eat the rich vegetation that grew there. As the herds of bison passed through, they would compact the soil and keep vegetation short by eating the tips of the grasses. This created an ideal habitat for the prairie dog because they need compacted soil to make effective burrows, and they prefer to live where vegetation is kept short. If the population of prairie dogs got too large, young adults would follow the trail of cleared vegetation left by the bison to create a new colony.

Figure D1.18: Prairie dogs are social animals.

There is a relationship between bison and prairie dogs that biologists call **symbiosis**. Clearly, relationships formed between organisms are important biotic factors in an environment. Symbiosis means "living together."

- symbiosis: a long-lasting, ecological relationship that benefits at least one organism of two different species that live in close contact
- mutualism: a symbiotic relationship in which the organisms of both species benefit

When two species live close together in a relationship in which both species benefit, it is called **mutualism**. The nitrogen-fixing bacteria that live on the roots of some prairie plants are an example of mutualism because the plant benefits from the nitrogen provided by the bacteria, while the bacteria utilize some nutrients in the plant roots. As for the prairie dog and bison, both species benefit from the relationship; but some biologists might argue that this is not the best example of mutualism. This is because an individual prairie dog does not have a long-term association with an individual bison.

Practice

17. Explain why prairie-dog towns have been called the grocery stores of the prairies.
18. Provide at least three examples of mutualism between human beings and other organisms. In each case, describe how each organism benefits.

Other Forms of Symbiosis

Cowbirds follow herds of bison to feed on the insects stirred up and flushed out of the grass from the bisons' hooves. Although the bison are largely unaffected by the feeding cowbirds, the cowbirds do benefit from an association with the bison because their feeding is enhanced. This form of relationship is referred to as **commensalism**.

Figure D1.19: Cowbirds feed on insects stirred up by bison and livestock.

The important thing to keep in mind here is that it is the relationship between the two species rather than the identity of the particular species, that determines what type of symbiosis is occurring. Cowbirds have a relationship of commensalism with the bison, but their relationship with other birds, such as the yellow warbler, is classified as **parasitism**.

- commensalism: a form of symbiosis in which one organism benefits, and the other organism is neither helped nor harmed
- parasitism: a symbiotic relationship in which one organism, called the parasite, derives benefit at the expense of another organism, called the host

Figure D1.20: Yellow warblers can unknowingly hatch the eggs of cowbirds.

Since cowbirds follow wandering herds of bison in search of insects, they don't have time to build their own nests or tend to their young. So the female cowbird deposits one of her eggs into another bird's nest, such as a yellow warbler. The yellow warbler then unknowingly incubates the cowbird egg along with her own. The parasitic cowbird chick usually hatches first and then grows quickly because it gobbles up most of the food brought to the nest by its foster parents. This results in the chicks of the host birds either starving or being pushed out of the nest by the larger cowbird chick.

Practice

Use the following information to answer questions 19 and 20.

The purple coneflower is a prairie wildflower known for its long-lasting blossoms and resistance to drought. As butterflies visit this plant in search of sweet nectar, they help transfer pollen from one plant to the other. This aids the production of seeds.

Figure D1.21: Purple coneflowers, goldfinches, and monarch butterflies are all connected.

The seeds are a favourite of the goldfinch and are a good source of food energy. Parts of the purple coneflower are valued by humans as well. First Nations people, who lived on the prairie grassland and followed the herds of bison, used the roots and leaves of this plant for medicinal purposes. Today, you can buy the herbs made from this plant under the Latin name for the purple coneflower—Echinacea purpurea.

19. Consider each of the following descriptions of symbiotic relationships between organisms. In each case, determine whether the relationship is mutualism, commensalism, or parasitism.
    a. A purple coneflower attracts monarch butterflies through its sweet nectar. By transferring pollen, the butterflies aid the coneflower in seed production.
    b. Several nematodes have attached themselves to the roots of the purple coneflower plant. The nematodes feed by sucking nutrients from the roots. This has the effect of stressing the plant, causing it to produce fewer seeds.
    c. Joseph carefully removes the dead leaves from the bottom of a purple coneflower plant in his garden to keep it healthy. He then carefully dries the leaves and takes a course to learn how to prepare the herbal medicine called Echinacea purpurea.
20. Monarch butterflies protect themselves from birds through chemicals in their bodies that the birds find distasteful. By experimenting, birds learn to avoid monarchs and their distinctive colouration. The viceroy butterfly mimics the colouration of the monarch even though it does not contain the foul-tasting chemicals of the monarch. Determine the symbiotic relationship between monarch butterflies and viceroy butterflies.

Predator-Prey Interactions

Up to this point, the discussion of the interactions between organisms has involved species that are in close association. Remember that symbiosis means living together, which implies that the interaction is long lasting.

Red-tailed hawks and prairie dogs do not live together and the interaction between them is not long lasting: a red-tailed hawk dives on a prairie dog with its talons extended to pierce the prairie dog's vital organs. This causes almost immediate death. This kind of an interaction is called **predation**. It is fairly clear how this kind of interaction benefits the predator, whereas it is difficult to see any benefit to the prey. However, if you think beyond the individual, there are benefits to the population of the prey species. Since individuals killed by hawks are often old, sick, and generally less-fit members of the population, this means that healthier, faster, and fitter individuals will survive and produce offspring with similar attributes. Another example of a predator-prey relationship involves lynx and hare populations. In the next investigation you will analyze data for lynx and hare populations over a period of 90 years.

predation: an interaction where one organism, the predator, kills and eats another organism, called the prey

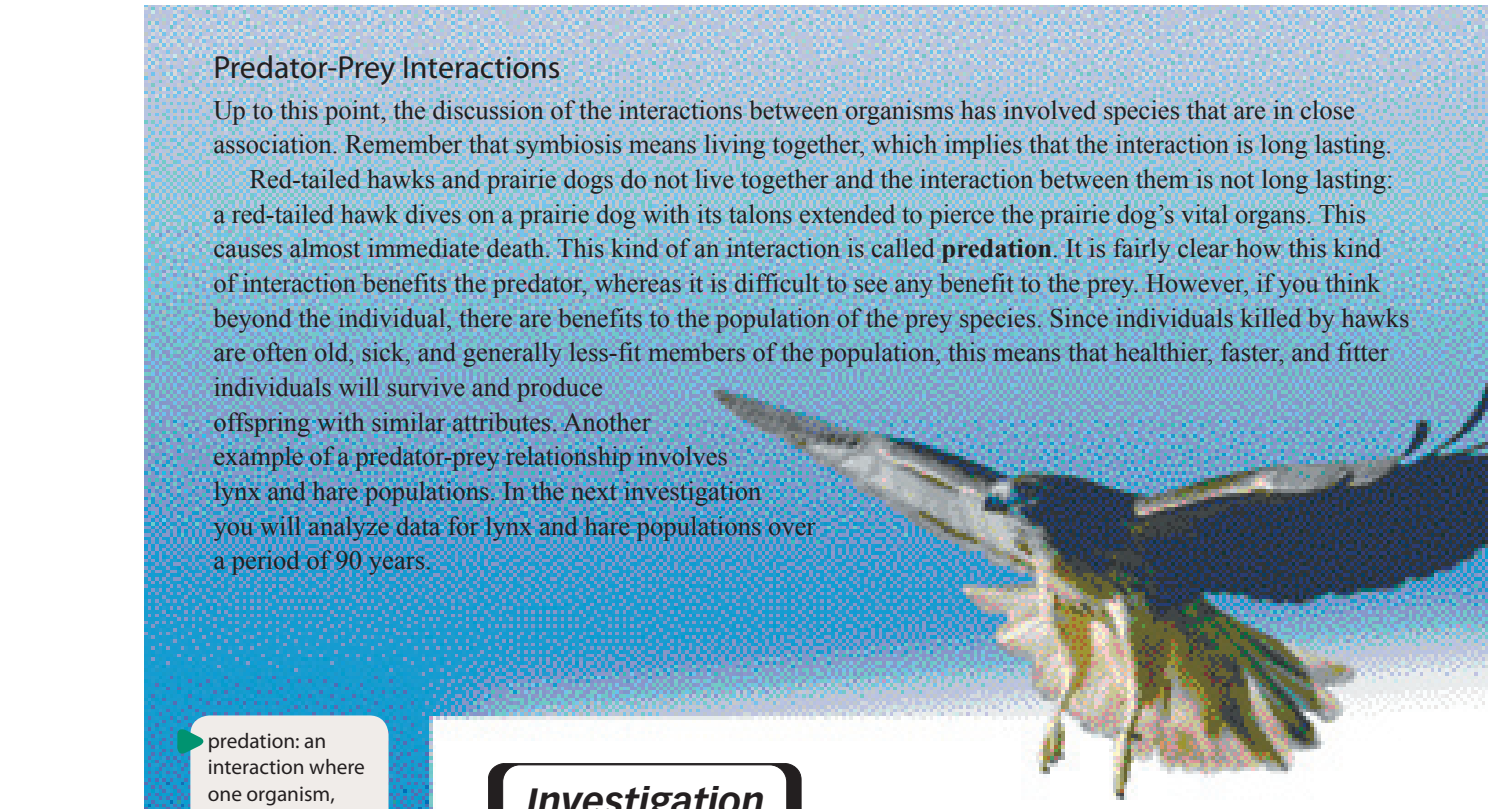
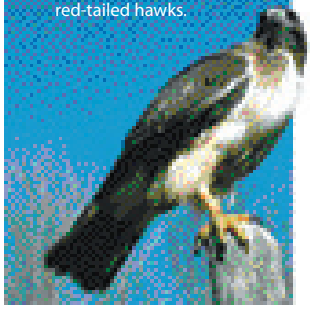


Figure D1.22: The population of prairie dogs is held in check by the predation of red-tailed hawks.



Investigation

Predator-Prey Population Dynamics

Purpose

You will identify and analyze data trends for the population of lynx relative to the population of snowshoe hares.

Science Skills

✓ Analyzing and Interpreting

Background

North of the prairie grasslands is a region of spruce forests and wetlands that biologists refer to as boreal forest. On a map of Alberta, this region stretches north from Edmonton and covers almost half of the province.

Figure D1.23: Boreal forests make up a large part of Alberta.

Major rivers, like the Athabasca, drain north through this region on their way to the Arctic Ocean. This region gets more precipitation than regions further south, so the landscape is heavily forested and is covered by bogs and muskeg.

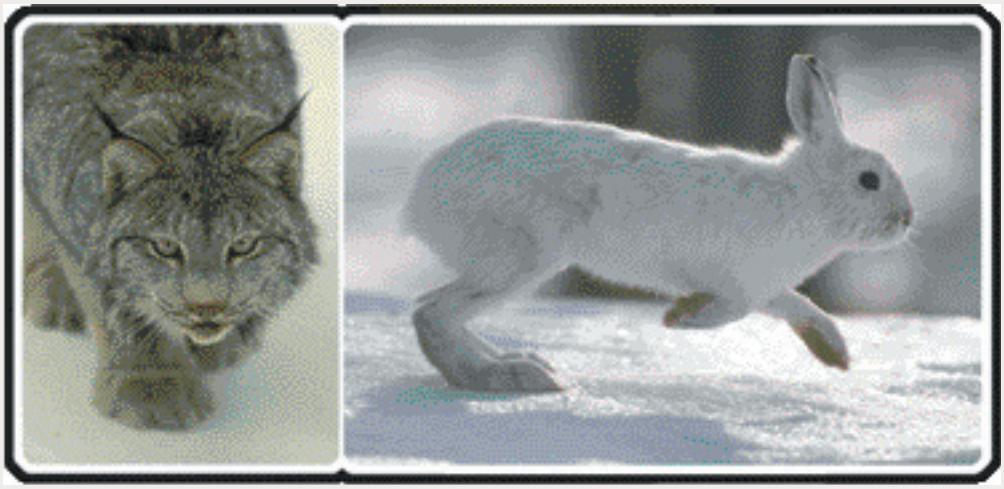


Figure D1.24: The lynx preys almost exclusively on the snowshoe hare.

Both the snowshoe hare and the lynx have found the boreal forest to be a favourable habitat. The lynx preys almost exclusively on the snowshoe hare. A valuable source of information regarding the population of these animals can be obtained from the fur-trading records of the Hudson's Bay Company. The number of pelts brought to the trading posts by First Nations and Métis trappers is an indicator of the rise and fall for the populations of both snowshoe hares and lynx. Fur trapping in many northern communities continues to be an important economic and cultural activity.

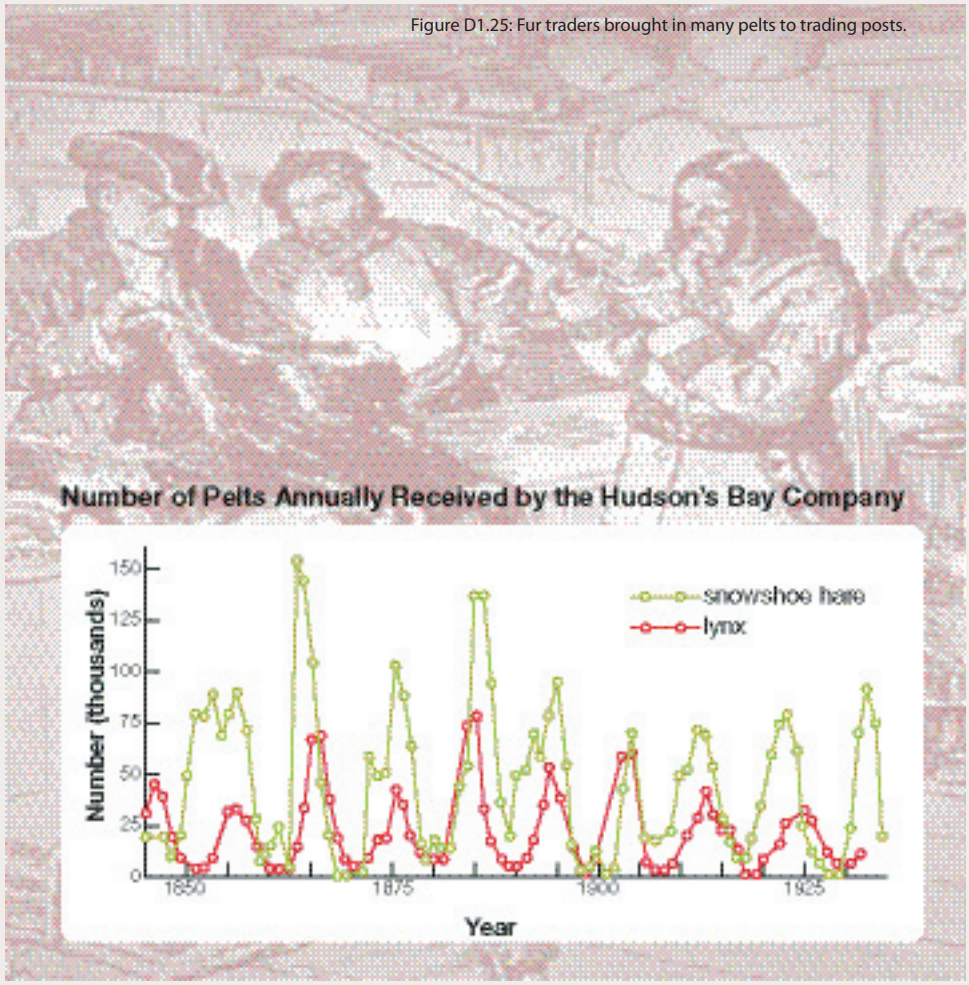


Figure D1.25: Fur traders brought in many pelts to trading posts.

In this investigation you will assume that the number of pelts is proportional to the number of individuals in each population. In other words, if the number of pelts doubles over a period of time, the number of individuals in the total population also doubles.

Analysis

1. Consider the data for the snowshoe hare.
   a. Identify the years in which the hare population peaked.
   b. Describe the overall trend displayed by your answer to 1.a.
2. Consider the lynx data.
   a. Identify the years where this population peaked.
   b. Describe the overall trend displayed by your answer to 2.a.
3. Compare the lynx data to the snowshoe hare data.
   a. At any given time, how does the number of snowshoe hares compare to the number of lynx? Concisely explain your answer.
   b. In question 1.b., you identified a cycle within the population of snowshoe hares. Concisely explain why a parallel cycle is found in the lynx population.
4. If a virus caused the entire snowshoe-hare population to disappear, predict what the likely effect on the lynx population would be.
5. Identify factors other than predator-prey interaction that may affect the size of the snowshoe hare or lynx populations.

Extension

6. Researchers have suggested that predator-prey relationships may be an effective way to manage wildlife in national and provincial parks. Identify reasons that support this statement.

Competition

competition: an interaction in which two or more organisms compete for the same limited resource

Although the lynx is the snowshoe hare's primary predator, it is not the only one. The great horned owl is a nocturnal hunter that preys heavily on the snowshoe hare. Since the number of snowshoe hares is limited, interaction between the lynx and the great horned owl is called **competition**.

Unlike a predator-prey interaction in which one organism clearly benefits, biologists classify competition as an interaction that harms both organisms because they each have to expend energy in a struggle to obtain the limited resource. In the case of the lynx and the great horned owl, if the population of snowshoe hares declines, both of these hunters will have to use more of their energy reserves to find their prey.

Examples of competition can also be found in the prairie grassland ecosystem. Grasses and wildflowers—such as the purple coneflower—compete for light, water, and soil nutrients. Since neither species benefits, this is not classified as a type of symbiosis, even though the plants live in close proximity over a long time frame.

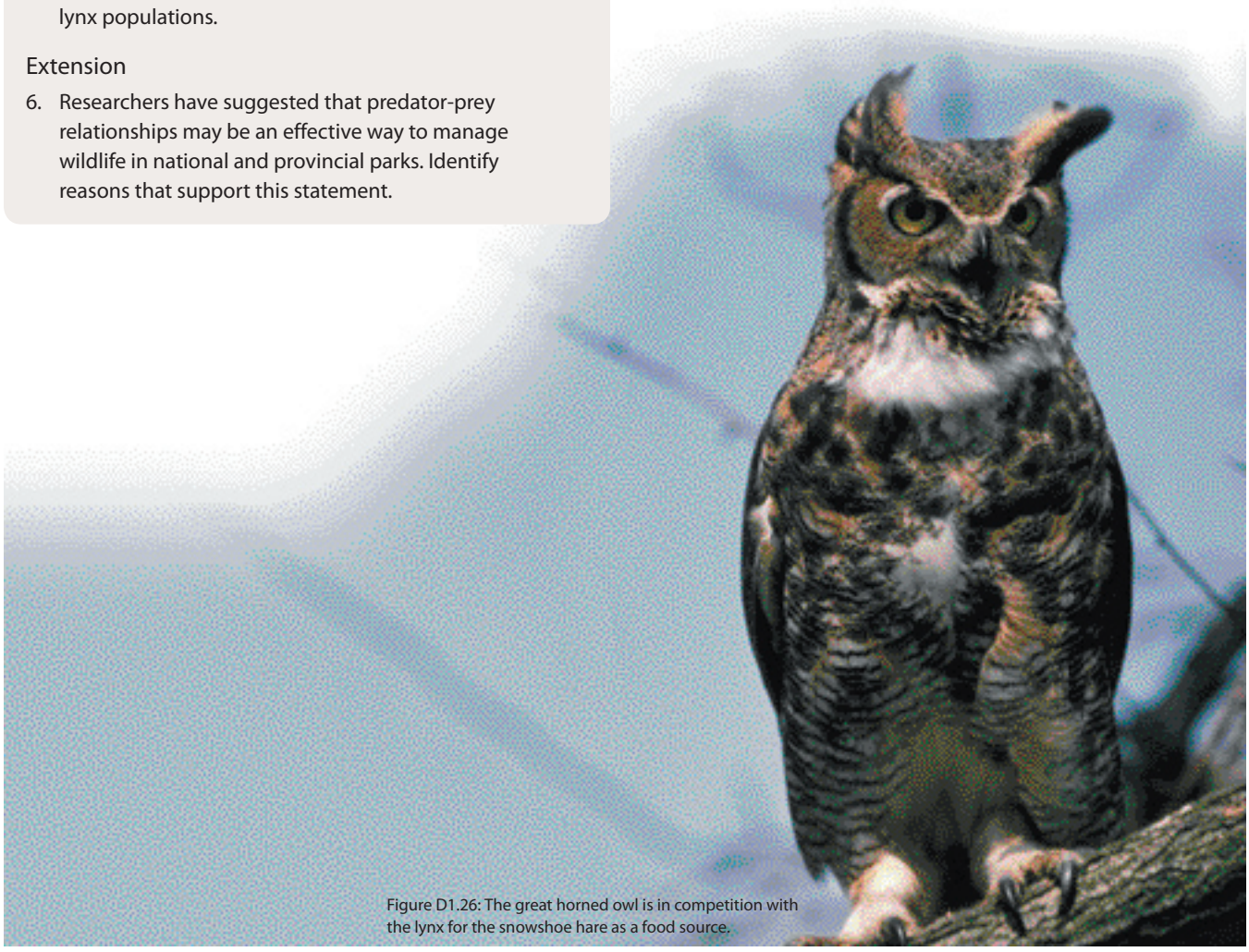


Figure D1.26: The great horned owl is in competition with the lynx for the snowshoe hare as a food source.

1.2 Summary

As you have seen from an in-depth look at a prairie grassland ecosystem, the organisms' presence, interactions, and wastes all have an impact. Collectively, all these influences that stem from the presence of living things are called biotic factors. Some of the interactions that exist between different species within an environment are known as symbiotic relationships. These are long-lasting, ecological relationships between two different species living in close contact. At least one of the organisms benefits from the interaction in the three categories of symbiotic relationships—mutualism, commensalism, and parasitism.

Besides symbiosis, another kind of relationship between organisms is called predation. Predation involves the death of one of the organisms—the prey—to provide nutrients for the other organism—the predator. Competition is the relationship that occurs when organisms living in an ecosystem compete for limited resources and nutrients.

1.2 Questions

Knowledge

1. Define each of the following words or phrases, and provide an example.

- **a.** biological community
- **b.** population
- **c.** mutualism
- **d.** commensalism
- **e.** parasitism
- **f.** competition
- **g.** predation

2. What is the difference between predation and parasitism?

3. Explain the importance of sunlight as an abiotic factor in terrestrial ecosystems.

Applying Concepts

Use the following information to help you answer questions 4 to 6.

Each question contains a description of an interaction or association between two species. For each description, complete the following steps:

- Identify the type of relationship between the two species.
- Explain the relationship by determining any benefit or harm to each species.

4. The sea anemone is a marine organism that looks like a flower. In reality, it has dozens of stinging tentacles that it uses to sting its food and drag this food to its mouth. The clown fish is immune to the stinging because of a special mucous coating its body. The clown fish lives within the jungle of stinging tentacles, which provides it with shelter from predators. The clown fish also eats the parasites that feed on the tentacles of the sea anemone.

5. You may have noticed that grass has a difficult time growing both under and around the base of spruce trees. Both the grass and the spruce trees need water and other essential nutrients to stay healthy. In the end, both species can show signs of stress from attempting to live too closely together.

6. Many people suffer from athlete's foot, which is a skin infection caused by a fungus. The fungus absorbs nutrients from the person's skin. This infection causes the feet to feel hot and itchy as the skin becomes irritated and often starts to peel.